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THESIS

AN ANALYSIS OF THE RELATIVE PRODUCTIVITY
OF OFFICERS FROM
DIFFERENT ACCESSION SOURCES

by

Michael J. Foster

June 1990

Thesis Advisor: Stephen L. Mehay

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An Analysis of the Relative Productivity of Officers From Different Accesion Sources

by

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of the requirements for the degree of

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ABSTRACT

This thesis compares the relative productivity of Naval Officers from the U.S. Naval Academy, Naval Reserve Officer Training Corps (NROTC), and Officer Candidate School (OCS). This is accomplished by creating a performance index for each individual based on officer fitness reports. The effects of commissioning source on performance are evaluated using multivariate analytical techniques. The results of the empirical analysis support the conclusion that Naval Academy graduates outperform NROTC or OCS graduates based on the measures used in this thesis. However, the magnitude of performance differences across commissioning source were small. Differences in performance were also found between year groups and for those officers who held warfare or engineering qualifications versus those who did not. It is recommended that further research be conducted on the marginal costs of each officer commissioning source to assist the Navy in making informed decisions concerning the future of commissioning programs.

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I. INTRODUCTION

A. BACKGROUND

The United States Navy has found itself poised at the beginning of an era that may be unlike any other in recent history. It is in the midst of major budget and force reductions that have been brought about by two unrelenting forces. First, The Gramm-Rudman-Hollings Amendment requires that the national deficit be eliminated by the year 1993. The Department of Defense, and subsequently the Navy, will absorb a large part of these reductions. Second, many believe there is a reduced threat from the Soviet Union and the Warsaw Pact countries. This has brought about demands by many public officials for reduced defense spending and the acceptance of a "peace dividend."

These two forces will continue to push the Armed Services to reduce both officer and enlisted end-strength, and to find more efficient and less costly alternatives to man, train, and support active-duty and reserve forces. The final result is that budget allocations, no matter what program is involved, will be scrutinized to an even finer detail than perhaps ever before.

The federal military academies and other officer commissioning programs will not be excluded from this scrutiny. Talk of personnel reductions have only recently

begun, yet the Senate Committee on Armed Services has already begun to review ways to reduce spending at the federal military academies and to reduce the number of students attending officer training classes. In the words of Senator James Exon (D., Neb.), "We're going to have to do something about [newly commissioned] officers coming through the system as though nothing has changed in East-West relations."(Pasztor 1990, A10)

Three of the Navy's primary commissioning sources that are sure to be subjected to attempted budget and student reductions are the United States Naval Academy (USNA), the Naval Reserve Officer Training Corps (NROTC), and Officer Candidate School (OCS).

It is not the intent of this thesis to determine how or where cuts should be made, or which commissioning programs produce the "best" officers. The goal of this thesis is much simpler: to begin the long stretch of research that is necessary for the Navy to make informed decisions concerning the future of commissioning programs.

B. OBJECTIVES

The objective of this thesis is to compare the relative productivity of Naval Officers from three major commissioning sources: USNA, NROTC, and OCS. This is accomplished by creating a performance index for each individual based on officer fitness reorts. The effects of commissioning source

on performance are evaluated using multivariate analytical techniques.

C. SCOPE, LIMITATIONS, AND ASSUMPTIONS

The surface and submarine warfare communities were chosen for this study because they represent highly technical fields and they are recipients of a large number of newly commissioned officers as compared to the Supply Corps or General Unrestricted Line community. This is not to say that the aviation community is not of a technical nature, or that it is an undesirable community; in fact, it is very popular. The aviation community was excluded from this study because the Aviation Officer Candidate School (AOCS) was inadvertently omitted from the initial random sample of officers provided by the Navy Personnel Research and Development Center (NPRDC). If the effects of commissioning source in the aviation community had been examined without including officers from AOCS, the results would not have been representative of that community.

A potential limitation of this study is the nature of the measure used to gauge job productivity of officers. It assumes that fitness reports yield accurate measures of productivity. In the private sector, one would be able to use pay as a measure of productivity; however, in the military, all officers of the same rank receive the same base pay, so pay cannot be used to differentiate performance differences.

Therefore, measures derived from officer fitness reports are a helpful source of information on officer performance.

D. ORGANIZATION OF THE STUDY

Chapter Two contains a review of pertinent literature. The literature discussed provides the background for the development of the performance indices used in this thesis.

Chapter Three describes the formulation and content of the officer data set and a detailed explanation of the research methodology utilized.

Chapter Four presents the empirical results from the multivariate analysis.

Chapter Five presents conclusions that are derived from the multivariate analysis. It also includes recommendations for further research.

II. LITERATURE REVIEW

A. GENERAL INFORMATION

Previous research on officer productivity has been limited to the extent that it is virtually nonexistent. However, some studies have examined officer fitness reports in a number of ways. Topics range from a survey of officers, requesting their opinions on the officer fitness report system (Hearold et al. 1984), to a comparison of U.S. Marine Corps officer performance by commissioning sources (Armel 1988). Although the objectives of most of the previous studies are not the same as that of this thesis, the information they contain has been helpful in many ways.

One of the most important items to be gained from the previous literature is the development of a methodology for comparing officer performance. There are three primary characteristics of officers identified in the previous literature that are statistically as well as intuitively appealing as comparative indicators.

First, performance indices, derived from specific aspects of officer fitness reports, allows officers to be compared or ranked with one overall grade. There are concerns that the reported high degree of "grade inflation" on officer fitness reports may make them useless for deriving a performance

index.[1] However, detailers have stated that "it is easy to identify the top and bottom promotion candidates, but difficult to distinguish among the middle crunch (Bjerke et al. 1987, 17)." This shows that officer fitness reports display enough variation among individuals so that they can be used to develop a performance index.

Second, an examination of officer promotability may yield some interesting notions concerning which officer characteristics are associated with above-average promotion rates (Hale 1990).

Third, a review of officers retained beyond an initial obligation period may also provide another indicator of performance differences across officers (Bowman 1990 and Hale 1990).

The remainder of this chapter examines how these three methods of differentiating officer performance have been applied in previous studies.

B. THE PERFORMANCE INDEX

The "Rickover Hypothesis" states that the best naval officers are those with technical engineering, mathematics, or science degrees (Bowman 1990, 272). William R. Bowman tested this hypothesis on a sample of 1,560 graduates from the

[1]In a survey conducted by Hearold et al. 1984, 95 percent of the survey respondents felt grade inflation was a problem (Hearold 1984, vii).

U.S. Naval Academy (USNA), classes 1976-80, who were in the surface or submarine warfare communities.

Bowman's focus was on junior officers who were being evaluated near the end of their first division officer tour. For most individuals, this would be near the end of the fourth year of service. An officer's fitness report had to meet two of three criteria to be included in Bowman's sample. The basis for observation had to be frequent and the occasion of the report had to be periodic/annual, or upon the detachment of the grading officer. This ensured all officers were evaluated against their peers.

Bowman developed two measures of "officer experience." The first was a performance index derived from officer fitness reports. He defined a "superior performer" to be an individual who met three criteria: (a) recommended for early promotion; (b) ranked in the top one percent in command desirability; and (c) ranked in the top one percent in the overall mission contribution/evaluation. According to Bowman, more discriminating criteria for determining "superior" officer performance are not available for junior naval officers (Bowman 1990, 274).

The second measure of officer experience examined by Bowman was retention. Specifically, he determined the probability that a junior officer would remain on active duty at least six months after expiration of an initial obligation. (Bowman 1990,274)

The data required for his study came from several sources. A longitudinal profile of officer fitness reports was obtained from the Navy Personnel Research and Development Center (NPRDC). Background data were taken from the Navy Officer Master/Loss file. (This was provided by the Defense Manpower Data Center, (DMDC).) Applicant and military performance data were obtained from Naval Academy admissions files and registrar files. (Bowman 1990, 273)

Using maximum likelihood models, Bowman first explains which graduates tend to enter which warfare community, as a test of the presence of potential selectivity bias. Models reflecting performance and retention are then estimated for both the surface and submarine communities.

Selectivity bias is the tendency for an individual with a particular background to make a conscious decision to choose between two or more alternatives. In this case, it is directed at the tendency for midshipmen to choose one warfare community -- nuclear versus surface -- over another based on their academic background.

To estimate officer selection into the warfare communities, Bowman used two academic measures: major and grade point average (GPA). By dividing academic major into several groups (engineering, mathematics/physical sciences, humanities/social sciences management/economics and general engineering/physical sciences) and basing academic achievement on a 4.0 scale, Bowman found that "academic majors and

academic achievement are significantly related to the decision to choose" between the nuclear and conventional communities (Bowman 1990, 278). Of particular note, Bowman finds that "management/economics majors are over 60 percent less likely to choose and be accepted into the nuclear Navy" (Bowman 1990, 279).

Bowman notes that an attempt to control for self-selection bias (using the Heckman procedure), did not affect the basic results. Therefore, he did not present the results of the attempt to control for self-selection bias. The Heckman procedure allows one to control for selection bias when some of the outcomes are not known. There are some officers of the Naval Academy who held the same academic background as those in the sample, but the results of their warfare community selection were not known.

Using several control variables, Bowman found some interesting results concerning officer performance and retention. For example, he found ship type to be occasionally significant in explaining both performance and retention. In particular, serving on aircraft carriers in relation to destroyers (for the conventional Navy) or ballistic missile submarines (for the nuclear Navy) increased the probability of being a superior performer. For retention, he found serving on nuclear cruisers and attack submarines (relative to ballistic missile submarines) increased the probability of retention in the nuclear Navy.

Whether or not an officer was warfare-qualified was also a significant determinant of performance and retention. Being warfare qualified increased the probability of being a superior performer by over 14 percent in the nuclear Navy and over 35 percent in the conventional surface Navy. Staying six months beyond the initial obligation period also increased the probability of being a superior performer by over 10 percent in the nuclear Navy and by 6 percent in the conventional surface Navy.

Race and marital status were also found to be significant control variables. Racial minorities were less likely to be superior performers, while blacks were more likely to stay in the Navy beyond their initial obligation. At the same time, married officers were less likely to stay beyond their initial obligation.

Using dummy variables for the officers' major field of study at USNA, Bowman found that, in general, "the Rickover hypothesis is not supported for either the conventional surface or nuclear surface/submarine warfare communities" (Bowman 1990, 282). Thus, Bowman concluded that there is little effect of an officer's academic major on the probability that the officer will be a superior performer or stay beyond his initial obligation.

Bowman presents two notable exceptions to this. In contrast to the Rickover Hypothesis, management/economics majors were <u>more</u> likely to be superior performers than

engineering majors, while being a general engineering/science major increased the probability of being retained.

Another interesting performance index was developed by Idell Neumann at the Navy Personnel Research and Development Center. The objective of Neumann's research was to expand the Naval Academy selection system to include predictors of later officer performance while in the fleet (Neumann et al. 1989). To accomplish this, she first had to determine a performance criterion to distinguish outstanding performers.

The data for the development of the performance index consisted of Naval Academy graduates during the 1979-82 period who served in the surface, submarine, and aviation warfare communities. These officers were chosen because they had at least four years of commissioned service, and because response data for instruments used in the selection program were available along with USNA selection and performance scores.

Neumann's research revealed many aspects of officer fitness reports that were highly skewed to the upper end of the evaluation scale. By computing "the proportion of occasions on which the officer received the highest possible rating," she determined that the category "recommended for early promotion" showed the greatest differentiation among individuals. Only 26 percent of the officers examined were recommended for early promotion over their entire fitness report file. For both command desirability and overall mission contribution/evaluation, over 58 percent received the

highest grade possible over their entire fitness report file. For other elements, the percentages were much higher. For example, Neumann points out that 79 percent of all officers received a top 1 percent evaluation in leadership, and 85 percent received a top 1 percent in tactical proficiency. (Neumann et al. 1989, 6)

Neumann went on to determine that differences in the mean performance index existed between grades, warfare communities, and year-groups. This prevented simply grouping all individuals together, so standard scores were created for each group and then the standardized scores were weighted by the number of reports an individual had received for each rank the officer had held during the three-year period. This gave each individual three standardized, weighted scores. These scores were then summed to give an individual one score that represented his or her entire fitness report history. (Neumann et al. 1989, 7)

The results of Neumann's study are not necessarily applicable to this thesis. However, there are some interesting results. For example, the ability of Scholastic Aptitude Test (SAT) scores to predict officer performance was found to be limited. On the other hand, recommendations from high school officials and extracurricular high school activities were found to have potential for predicting officer performance.

A third performance index was used by Lyle Armel in a Naval Postgraduate School thesis to compare performance differences of Marine Corps officers by commissioning sources. To determine the performance index for an individual, he summed all the scores received for blocks 13, 14 ,15b, and 16 on the fitness report, and then divided by the number of marks received. These blocks refer to "performance", "qualities", "general value to the service," "and the desire of the grader to have the officer serve in the grader's command during war." (Armel 1988, 11) The data for Armel's study consisted of the fitness reports for Marine Corps officers commissioned in 1976-87, from the Naval Academy, NROTC, Officer Candidate School, and enlisted commissioning sources.

Using multivariate analysis, Armel estimated the effect of commissioning source, general classification test score, gender, year commissioned, racial/ethnic group, geographic region, and military occupational specialty (MOS) on performance. Armel found no significant differences in performance between Naval Academy and NROTC graduates. However, there were differences between those officers commissioned from either an enlisted commissioning program or the officer candidate course and the Academy and NROTC. Geographic region, Hispanic ethnicity, and gender were not statistically significant, while all other variables were statistically significant.

C. PROMOTABILITY, RETENTION, AND INVOLUNTARY SEPARATION

The Congressional Budget Office (CBO) recently released an analysis of the major commissioning sources for the Army, Navy, and Air Force. The major sources consisted of the service academies, ROTC scholarship and non-scholarship programs, and officer candidate school (officer training school for the Air Force). This analysis was subsequently presented to the Subcommittee on Manpower and Personnel of the Committee on Armed Services, United States Senate, in a statement by Robert F. Hale, the Assistant Director for the National Security Division of the CBO. Hale's statement focused on the services' declining needs for new officers, the costs of various commissioning programs, and measurable performance differences of officers from different commissioning sources (Hale 1990, 1).

CBO used three measures to compare officers commissioned between 1979 to 1988: length of service, time to promotion, and involuntary separation. There were 255,000 officers with up to 10 years of service analyzed.

Using regression analysis, with some personal and career characteristics as control variables, CBO determined that academy graduates of all three services have greater average lengths of service than other commissioning sources.* Specifically, Naval Academy graduates on average served two

*The actual control variables used in this regression analysis were not explicitly listed.

months longer than NROTC scholarship graduates, and 16 months longer than NROTC contract graduates. (Hale 1990, 14)

Time to promotion also showed academy graduates to statistically perform at a higher level. In a comparison between services, the Navy showed the least variation across commissioning sources. There was virtually no difference between commissioning sources in time to promotion to pay grade O-3: all Navy sources averaged 26 months. For time to promotion to pay grade O-4, OCS graduates were statistically different: on average they took three months longer to promote. These results were also based on a regression analysis using education, marital status, number of dependents, race, sex, and primary military occupational specialty as control variables. The significance of the control variables was not presented in the CBO report.

The rate of involuntary separation is low service wide, but tends to be lowest for ROTC graduates. Within the Navy, OCS graduates held the highest rate at one percent. Academy graduates were next at one-half a percent. Based on these results, Hale concluded that no systematic differences in officer performance are apparent between academy graduates and others (Hale 1990, 17).

An examination of the costs for each commissioning program showed the service academies to be the most costly, followed by ROTC scholarship, non-scholarship, and OCS/OTS graduates. In his statement to the Senate subcommittee, Hale noted that

the average costs were not appropriate for all decisions. He cautioned the subcommittee members that the average costs would

> . . . overstate the effects of small changes in numbers of students, particularly at the academies. The academies incur substantial costs to maintain their facilities and basic educational services. Most of these costs would not change if there were small changes in the numbers of students. Assessing the effects of small changes in the numbers of students would require an estimate of marginal costs, which cannot be obtained using the data available to CBO.

The literature reviewed above has shown several methods to compare the performance of officers from different commissioning sources. There are advantages and disadvantages to each, which depend in part on the availability and usefulness of the data, and the complexity of the procedure. While the objectives of above studies were different from this thesis, the literature review indicates that there is no single "correct" or best procedure for measuring officer performance. The choice depends on the objective of each study. The data and procedures used in this thesis will be discussed in later chapters as outlined in the introduction.

III. DATA AND METHODOLOGY

A. DATA

1. The Officer Sample

The data file used for the statistical analysis was obtained from the Navy Personnel Research and Development Center (NPRDC), San Diego. The data file consists of a random sample (N=15,365) of Naval Officers from year groups 1977-87, who were commissioned from USNA, NROTC, both scholarship and contract programs, and OCS. Included in this sample were officers from all communities, both line and staff, with grades ranging from ensign to lieutenant commander.

The random sample was obtained by first listing in numerical order, social security numbers (SSNs) for officers who were commissioned from the above sources and applicable years. These SSNs were then divided into five arbitrary groups, from which a block of sequential SSNs were selected. Three of the blocks held 3,000 officer SSNs, which were then matched with data from the Officer Master File (OMF). The officer master file contains a variety of information. Grade, both present and permanent, designator, gender, educational achievements, qualifications, and dates of rank are examples of data available from this file.

The two remaining blocks contained 2,865 and 3,500 officer SSNs. These were matched with data from the attrition files,

which for each officer who had left the Navy, contained his or her officer master file and attrition data. This allowed officers who separated during this period to be included with those who had not.

The officer SSNs, selected attributes from the officer master file, and attrition files were then matched with every fitness report the officer had received during the period. In other words, an officer's master/loss file data were repeated for each fitness report. This created a file with over 183,000 records. SSNs were replaced by dummy identification numbers to protect the privacy of individuals. A report number (RPTN) was added to identify the fitness reports of each individual. The number of reports (NRPTS) associated with each officer is also noted. Figure 1 displays a diagrammatic representation of the data contained in the random sample. DUMMYID, RPTN, and NRPTS identify each record.

DUMMYID	RPTN	NRPTS	OMF DATA	FITNESS REPORT DATA
0000001	1	5	RANK ETC.	FITNESS REPORT 1
0000001	2	5	.	FITNESS REPORT 2
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
0000001	5	5	RANK ETC.	FITNESS REPORT 5

Figure 1. A Diagrammatic Representation of the Random Sample

Selected aspects of the officer master file (OMF) data, such as rank and commissioning source are also included. The entire fitness report field completes the record.

2. Representativeness

This random sample is considered representative of the corps of Naval officers. Women comprise approximately ten percent of the officer corps and blacks approximately four percent (Eitelberg et al., 1989). In the constructed sample, women and blacks comprise nine and four percent, respectively.

It is difficult to determine whether the sample is representative of other groups because of the method utilized to select the random sample. The distribution of designators cannot be compared with the Navy-wide distribution, because not all commissioning sources were selected. For instance, the aviation community in the sample will be underrepresented because Aviation Officer Candidate School was inadvertently omitted as a commissioning source. It was also beyond the scope of this thesis to examine other officer commissioning sources, such as the Aviati n Reserve Officer Candidate or Enlisted Commissioning programs.

3. Variables

The officer master/loss file contains much more information than is necessary for this analysis; therefore, only certain aspects of it were chosen. Table 1 shows a list a variables obtained from the officer master file and also presents information on how the sample of officers was

distributed by each variable. Original source code (OSC) delineates the program from which the officer received a commission: USNA, NROTC, and OCS, were selected for this thesis.

To separate officers into warfare communities, designator was selected from the officer master file. The initial sample consisted of 74 different designators. Since the subject of this thesis examines officers in the surface and submarine warfare community, only the designators associated with those two communities were kept.

Race was selected as a control variable. It should be noted that Hispanic is not included under the race variable, because it is considered an ethnic classification. While Hispanics are included in the sample, they are not distinguished from other groups.

Gender was chosen as a control variable, but women were eventually removed from the sample because of insufficient sample sizes once the report selection criteria were applied. The selection criteria for inclusion in the final sample are discussed below.

The officer master file allows 12 additional qualification designators (AQD) to be displayed for an individual. These designators identify certain skills and knowledge the officer has obtained throughout his career. The AQDs of interest are those describing major warfare and engineering qualifications:

TABLE 1. THE NUMBER AND PERCENTAGE OF VARIABLES OBTAINED FROM THE OFFICER MASTER/LOSS FILE

VARIABLES	FREQUENCY	PERCENT
ORIGINAL SOURCE CODE		
USNA	3604	26.9
NROTC	4611	34.4
OCS	5174	38.6
DESIGNATOR		
1110	2214	33.7
1115	1327	20.2
1120	1061	16.2
1125	377	5.7
1160	601	9.2
1165	627	9.5
1170	279	4.2
1175	85	1.3
RACE		
WHITE	14036	92.4
BLACK	633	4.2
OTHER	572	3.5
GENDER		
MALE	13815	90.9
FEMALE	1381	9.1
ADDITIONAL QUALIFICATION DESIGNATOR		
WARFARE QUALIFIED	5655	37.2
ENGINEERING QUALIFIED	2228	14.7
ACADEMIC MAJOR		
ENGINEERING	4286	28.2
GENERAL SCIENCE	3502	23.0
SOCIAL SCIENCE/MGMT	5825	38.3
HUMANITIES	1010	6.6

surface and submarine warfare qualification, and engineering officer of the watch or nuclear engineering qualified.

Undergraduate academic major was divided into four broad categories in accordance with the Manual of Navy Officer Classifications, NAVPERS 15839. Engineering consists of various types of engineering curriculum and architecture such as mechanical, chemical, and electronics. General Science consists of geology, biology, physics and so forth. The Social Science/Management category consists of history, foreign affairs, economics, public administration, etc. Finally, Humanities consists of fine art, English, and philosophy.

The information available from the officer fitness report file is much smaller compared to the officer master file. For ease of assembly, all available data on the officer fitness report file were obtained. Ship or station, all the evaluation categories, and personal information on both the receiving officer and the reporting senior were available from the fitness reports. An example of a Navy officer fitness report can be found in Appendix A.

4. Selection Criteria

Selection criteria had to be applied to eliminate reports which might bias the results of a multivariate analysis, since every fitness report received by an officer is in the original sample.

The first criterion was the occasion for the report. It was limited to either periodic, detachment of reporting senior, or both periodic and detachment of reporting senior. The second criterion was the type of fitness report. This was limited to regular, as opposed to concurrent or special.[1] The third criterion was the basis for observation of the officer. This was limited to close, as opposed to frequent or infrequent.

Using these criteria restricted the number of fitness reports used in the analysis to those in which the recipient of the report was evaluated with his peers. This also ensured that only meaningful reports are included in the file.

Although all relevant information on the fitness reports were available, only a limited amount was useful. An examination of the frequencies of top grades on evaluation criteria reveals the tendency for a high percentage of officers to be ranked in the upper categories. For example, on 90.7 percent of the reports the officers were given an 'A' in leadership.

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[1]A concurrent fitness report is usually used in conjunction with additional duty (ADDU), or temporary additional duty (TEMADD) exceeding a two month period, where the officer is not directly observed by the regular reporting senior. Special fitness reports are generally used to place information in an officer's record required by detailers or selection boards, for use before the regular periodic report date. (NAVMILPERSCOMINST 1611.1A, 1990)

This tendency for grade inflation is less serious in the recommendation for promotion, command desirability, and overall mission contribution/evaluation. The percentages of officer's receiving top grades in these categories were 50.5, 79.2, and 79.2, respectively. This made these three evaluation categories stand out as having potential to yield the greatest variation across individuals.

B. METHODOLOGY

The purpose of this thesis is to empirically examine differences in performance by commissioning source through the use of a performance index. This section details the construction of two performance measures.

1. *Performance Indices*

Following the work of Bowman and Neumann outlined in the literature review, two performance indices were developed. Bowman's index consists of defining an individual as a superior performer if he is given the highest evaluation on three elements of the fitness report: recommendation for promotion, command desirability, and overall mission contribution/evaluation. A binary variable is coded "one" for individuals who are superior performers and "zero" otherwise. This provides a dichotomous dependent variable for a multivariate regression model. Since the dependent variable is binary, maximum likelihood multivariate techniques (logit) will be utilized to estimate the parameters of the model.

A second performance index was constructed based on previous work by Neumann. This index was constructed by calculating the percentage of occasions on which the officer was recommended for early promotion during the entire period he was observed. This index provides a continuous dependent variable, which allows the ordinary least squares estimating technique to be utilized.

While one data set could have been used for both indices, it was much easier to create separate data sets for each dependent variable. The basis for this is the way the performance indices are constructed. Bowman's index is measured at a point in time relevant to that officers commissioning date and it consists of only one fitness report. Neumann's index is measured over an officer's career, and consists of all fitness reports that met the selection criteria.

2. Data set for the Bowman Index

For the Bowman index, lieutenants from the surface and submarine warfare communities were chosen near the end of their fourth year of service. By eliminating missing or bad data and questionable observations, the number of observations were reduced to 2,158. From this final sample the dichotomous dependent variable was created.

Maximum likelihood (logit) models were estimated for each warfare community. The explanatory variables were composed of dummy variables for warfare and engineering qualifications,

academic major, race, and year group. In addition, three dummy variables were created for commissioning source. The models explain the probability that a junior officer will be a superior performer depending on his commissioning source.

3. Data Set for the Neumann Index

Construction of the data set for the Neumann index is much more complicated. It is derived from all fitness reports that met the selection criteria.

A continuous dependent variable was computed that measured the percentage of occasions that an officer received the highest possible rating on three separate elements: recommendation for early promotion, command desirability, and overall mission contribution/evaluation.

Recommended for early promotion clearly provides the greatest variation between officers, with only 22.6 percent of the officers in the sample receiving an early promotion recommendation on every relevant fitness report. Over 50 percent received the highest evaluation on command desirability, and the overall mission contribution/evaluation.

As in the previous model, dummy variables were created for original source code, warfare and engineering qualifications, academic major, race, and year group. These dummies were used as control variables in ordinary least squares multivariate regressions, which attempted to isolate the effect of commissioning source on performance.

4. RETENTION

A third indication of performance was also examined: the probability that a junior officer will remain on duty at least one year beyond his initial minimum service requirement. If officers stay beyond their initial period of obligated service, the Navy receives an additional return on its training investment. A dichotomous dependent variable was created based upon their retention pattern. If they stayed at least one year beyond their minimum service requirement, then they were coded a "one", otherwise "zero". Coding the dependent variable in this manner allowed maximum likelihood multivariate analysis (logit) to be utilized.

The results of the above models are be discussed in the following chapter.

IV. EMPIRICAL ANALYSIS

A. BIVARIATE ANALYSIS

Bivariate analysis may not yield the same results as multivariate techniques, but it is useful because it provides a starting point for better understanding the relationship between the dependent and explanatory variables. This section examines the distribution of the dependent and explanatory variables, as well as crosstabulations of performance and personal characteristics.

1. The Distribution of Officers by Performance

The distribution of officers according to the Bowman Index is fairly uniform, with 54 percent of the final sample being rated superior. At first thought, this index may not seem to be an accurate method to differentiate performance between officers because over half of the officers are rated superior. While this implies that some degree of grade inflation exists, the Bowman Index is suitable for use as a dependent variable in a multivariate regression.

There appear to be significant differences in the proportion of officers rated superior across commissioning sources, academic majors, year groups, and races. Of the officers commissioned from USNA, over 58 percent were rated superior, while 52 and 49 percent were rated superior from NROTC and OCS, respectively. If these are statistically

significant differences, this implies that USNA graduates outperform officers from the other commissioning sources.

Table 2 shows the distribution of officers rated superior by academic major. A higher percentage of officers with engineering degrees (Eng.) were rated superior as compared to social science/management (Soc. Sci.), general science (Gen. Sci.), or humanities majors (Hum.), in that order. This suggests that engineering majors may be higher performers, particularly as compared to humanities majors.

TABLE 2. PERCENTAGE AND NUMBER OF OFFICERS RATED SUPERIOR WITHIN ACADEMIC MAJORS

Officers Rated Superior	Eng.	Gen. Sci.	Soc. Sci.	Hum.
Percent	58.5	52.5	50.3	36.7
Number	531	267	287	43

The most drastic difference in performance occurred between the white and non-white groups. Over 54 percent of whites were rated superior, in contrast to only 36 percent of non-whites.

Table 3 displays an interesting trend that appeared while examining performance over year groups. While approximately 26 percent officers in year group '77 were rated superior, the percentage of officers rated superior increases in every

subsequent year group. Almost 70 percent of officers in year group '85 were rated superior.

TABLE 3. NUMBER AND PERCENTAGE OF OFFICERS RATED SUPERIOR IN YEAR GROUPS '77-'85

Year Group	Number	Percent
'77	44	26.3
'78	64	36.2
'79	86	47.0
'80	115	49.1
'81	127	52.5
'82	151	53.0
'83	197	68.4
'84	193	61.9
'85	188	69.6

2. The Distribution of the Neumann Index

The Neumann Index is uniformly distributed between the extremes of 0.0 and 1.0, with a mean of .49. Therefore it is suitable as a dependent variable for ordinary least squares estimation. Table 4 shows the distribution of officers on the Neumann index.

Many of the same time trends that were present in the Bowman Index were also present in the Neumann Index. However, caution should be exercised in trying to compare the indexes

TABLE 4. FREQUENCY AND PERCENTAGE DISTRIBUTION OF OFFICERS BY THE NEUMANN INDEX

PI SCORE	FREQUENCY	PERCENT
0.0	218	12.7
0.1	74	4.3
0.2	160	9.3
0.3	137	8.0
0.4	177	10.3
0.5	178	10.3
0.6	142	8.3
0.7	220	12.8
0.8	155	9.0
0.9	113	6.6
1.0	144	8.4
Total	1718	100.0

because they do not capture the same aspects of officer performance. The Neumann distribution will be discussed by noting the percent of officers who received a 1.0 index versus examining the entire distribution for each dummy variable. An index value of 1.0 indicates officers who were recommended for early promotion on <u>every</u> fitness report evaluated.

Of officers commissioned from NROTC, 10 percent received a performance index of 1.0. However, approximately eight percent of USNA graduates and seven percent of OCS graduates received a 1.0. This suggests that, if statistical

differences exist between commissioning sources, that NROTC graduates perform at a higher level. This is different from the distribution of officers from various accession sources using Bowman's index.

The proportion of officers in each academic major receiving a 1.0 performance index was similar to the percentages obtained with Bowman's Index. According to this bivariate measure, as seen in Table 5, engineering majors out-performed social science/management, general science, and humanities majors. The difference was greatest between engineers and humanities majors, where the proportion engineers receiving a 1.0 was nine percentage points greater.

TABLE 5. PERCENT AND NUMBER OF OFFICERS RECEIVING A NEUMANN INDEX OF 1.0 WITHIN ACADEMIC MAJORS

Officers Receiving A 1.0 Index	Eng.	Gen. Sci.	Soc. Sci.	Hum.
Percent	10.4	8.9	7.8	1.4
Number	52	35	49	2

Again there appears to be a large difference between white and non-white groups. Over nine percent of whites received a 1.0 performance index, compared with fewer than two percent of non-whites.

While the Neumann index takes into account the passage of time by computing the performance index over an officer's career, there is still a trend of increasing performance over year groups. This trend is shown in Table 6.

TABLE 6. NUMBER AND PERCENTAGE OF OFFICERS RECEIVING A NEUMANN INDEX OF 1.0 IN YEAR GROUPS '77-'85

Year Group	Number	Percent
'77	3	3.0
'78	2	1.6
'79	6	3.3
'80	10	4.9
'81	20	8.8
'82	29	11.0
'83	27	11.3
'84	24	11.3
'85	23	16.3

One comparison measure that is available only with the Neumann index is a comparison of the mean performance index between warfare communities, grades, and year groups. Table 7 suggests that differences exist between the sub-groups and that simply grouping all individuals together may bias the results of a multivariate regression. This provides some justification for estimating separate models for each

community and for weighting by the number of reports received for each grade, as discussed above in the methodology section.

TABLE 7. THE MEAN NEUMANN PERFORMANCE INDEX BY YEAR GROUP, GRADE, AND COMMUNITY

Year Group	Surface ENS.	Surface LTJG.	Surface LT.	Submarine ENS.	Submarine LTJG.	Submarine LT.
'77	.258	.377	.418	.133	.242	.418
'78	.171	.349	.519	.040	.200	.483
'79	.235	.355	.512	.125	.443	.613
'80	.223	.400	.540	.235	.500	.723
'81	.267	.471	.579	.225	.489	.681
'82	.283	.455	.592	.402	.604	.805
'83	.244	.477	.607	.404	.652	.807
'84	.317	.535	.674	.320	.781	.709
'85	.349	.579	.651	.467	.833	.943

3. The Distribution of Officers by Retention

There is practically no difference between USNA and NROTC graduates in the percentage of officers who stayed at least one year beyond a minimum service requirement. However, a noticeable difference exists between USNA and OCS graduates. The percentage of OCS graduates remaining on active duty at least one year past their minimum service obligation is only 18 percent versus 23 percent of USNA graduates and 22 percent of NROTC graduates.

There is a slight difference in the number of officers remaining on active duty at least one year past an initial service obligation when compared by academic major. Table 8 shows this distribution. The entire spread is less than nine percentage points. However, there may be a statistically significant difference between academic majors, where general science majors may be more likely than other academic majors to service past their minimum service obligation.

TABLE 8. PERCENTAGE AND NUMBER OF OFFICERS REMAINING ON ACTIVE-DUTY AT LEAST ONE YEAR BEYOND AN INITIAL MINIMUM SERVICE REQUIREMENT BY ACADEMIC MAJOR

Retained Officers	Eng.	Gen. Sci.	Soc. Sci.	Hum.
Percent	21.4	24.4	19.8	15.9
Number	107	96	125	22

There appears to be a large difference in the retention tendencies of racial groups. In this sample, 21 percent of whites remained on active duty, while only 14 percent of non-whites remained at least one year past a minimum service obligation.

An interesting trend also occurs between year groups with this dependent variable. Each subsequent year group has a lower proportion of officers being retained at least one year beyond an initial minimum service. Table 9 shows this distribution.

TABLE 9. NUMBER AND PERCENT OF OFFICERS RETAINED AT LEAST ONE YEAR BEYOND A MINIMUM SERVICE REQUIREMENT IN YEAR GROUPS '77-'82

Year Group	Number	Percent
'77	34	33.7
'78	45	35.2
'79	66	36.3
'80	43	21.2
'81	57	25.2
'82	58	22.0

B. MULTIVARIATE ANALYSIS

Maximum likelihood (logit) models were estimated using the dependent variables created by the Bowman performance index and the retention variable. Ordinary least squares estimators were used to model Neumann's performance index. Each model was estimated for a pooled sample consisting of both warfare communities, and separately for each community. A discussion of the general results of these estimations is presented in this section. Appendix B presents the complete results of estimating the models.

Likelihood ratio tests for the binary dependent variable models and chow tests for the continuous dependent variable models were conducted to determine if the regression equations were identical for the two separate warfare communities.

Appendix C explains how these tests were conducted and the test results. In summary, statistically significant differences between the regression equations depend on the selected confidence level. Because the results are not clear cut, the results of estimating both the pooled and separate community models are presented.

The logit equations were transformed into probabilities by setting the explanatory variables equal to zero. In this manner, the probability of being a superior performer was established for a reference individual (the base case), who was a white Naval Academy graduate, with no warfare or engineering qualifications, and was an engineering major in year group '77. By changing the value of each explanatory variable from zero to one, computing the new probability of being a superior performer, and then taking the difference between the two probabilities a "delta" was obtained. This delta represents the change in the probability of being a superior performer when one of the independent variables (commissioning source, race, academic major, or year group) is altered from the base case.

1. Results of the Logit Models Using Bowman's Index

The effect of commissioning source on the probability of being a superior performer was found to be the most significant in the pooled model. In all models, USNA graduates were the base case. USNA graduates were more likely to be superior performers than NROTC or OCS graduates by 2.8

and 1.8 percentage points, respectively. OCS was not significantly different in either of the models for the separate warfare communities. However, NROTC graduates in the submarine community were 5.1 percentage points less likely to be rated superior performers, when compared to USNA graduates. Table 10 shows the effects of commissioning source relevant to USNA for all three models.

TABLE 10. THE CHANGE IN THE PROBABILITY (IN PERCENTAGE POINTS) OF BEING RATED A SUPERIOR PERFORMER FROM NROTC AND OCS RELATIVE TO THE NAVAL ACADEMY

Model	NROTC	OCS
Pooled Model	- 2.8 *	- 1.8 *
Surface Community	- 1.6	- 1.2
Submarine Community	- 5.1 *	- 4.4

* denotes significance at 0.10 level

The effects for the other explanatory variables using the Bowman Index can be found in Tables B.1 through B.3 in Appendix B. Warfare and engineering qualifications were statistically significant in all models estimated with the Bowman performance index. These effects were most significant in the pooled model. An officer who was qualified in his warfare speciality had almost a 17 percentage point increase in the probability of being rated a superior officer, while

having an engineering qualification increased the probability of being a superior performer by 7.9 percentage points. These effects are less dramatic in the surface and submarine community models, but are still statistically significant. Table 11 shows the effects of obtaining these qualifications for the three models.

TABLE 11. THE CHANGE IN THE PROBABILITY (IN PERCENTAGE POINTS) OF BEING A SUPERIOR PERFORMER FROM OBTAINING WARFARE AND ENGINEERING QUALIFICATIONS

Model	Warfare	Engineering
Pooled	16.8 *	7.9 *
Surface Community	14.5 *	6.2 *
Submarine Community	14.2 *	8.3*

* denotes significance at the 0.10 level

The effect of academic major on the probability of being rated a superior performer was mixed. Compared to engineering majors, humanities majors were 4.8 percentage points less likely to be rated superior in the pooled model, and 16.3 percentage points less likely in the submarine community model. Otherwise, there were no statistically significant differences between engineering majors and social science/management, general science, or humanities majors.

Race has a statistically significant effect on the probability of being a superior performer: non-white officers were less likely to be superior performers in all three models. This effect ranged from a four percentage point difference in the surface community to a nine percentage point difference in the submarine community.

The effect of year group was significant in all but two cases as shown in Table 12. Year groups '78 and '79 were not significant in the submarine community, but each subsequent year group increased the probability of being rated a superior

TABLE 12. THE CHANGE IN THE PROBABILITY (IN PERCENTAGE POINTS) OF BEING A SUPERIOR PERFORMER FROM YEAR GROUPS '78-'85 RELATIVE TO YEAR GROUP '77

Year Group	Pooled Model	Surface Community	Submarine Community
'78	4.6	7.7	1.5
'79	12.1	12.6	10.3
'80	14.4	12.4	19.5
'81	17.5	14.7	24.1
'82	18.6	11.9	35.3
'83	35.1	22.3	45.3
'84	25.2	19.1	38.8
'85	38.1	32.4	48.2

* All year groups are significant at the 0.10 level except '78 and '79 in the Submarine community.

performer as compared to the base case year group '77. The most dramatic increase occurred for year group '85 in the submarine community. Officers from this year group were more likely to be superior performers by over 48 percentage points as compared to year group '77 officers.

2. Results of the OLS Regression Models Using the Neumann Performance Index

The effect of commissioning source was more consistently significant in these models than those using the Bowman's index. These effects are shown in Table 13. In general, graduating from an NROTC program decreased the proportion of occasions recommended for early promotion by four percentage points, as compared to USNA graduates. A similar, but somewhat stronger effect was found for OCS graduates: graduating from this program decreased the proportion of occasions recommended for early promotion by six percentage points. Table 13 shows that the only occasion

TABLE 13. THE EFFECT (IN PERCENT) OF COMMISSIONING SOURCE ON NEUMANN'S INDEX

Model	NROTC	OCS
Pooled	- 4.8 *	- 6.2 *
Surface Community	- 4.0 *	- 6.4 *
Submarine Community	- 3.9 *	- 6.6 *

* denotes significance at the 0.10 level

commissioning source was not significant was in the submarine community where no statistically significant differences were found between NROTC and USNA graduates.

The full results from estimating the models using the Neumann Index can be found in Appendix B Tables B.4 through B.6. A warfare qualification increased the proportion of occasions that officers were recommended for early promotion in all three models by at least 22 percent, as shown in Table 14. While an engineering qualification increased the proportion by a minimum of almost 14 percentage points in the submarine community.

TABLE 14. THE EFFECT (IN PERCENT) OF QUALIFICATIONS ON NEUMANN'S INDEX

Model	Warfare	Engineering
Pooled	22.2 *	15.9 *
Surface Community	22.3 *	15.2 *
Submarine	22.6 *	13.5 *

* denotes significance at the 0.10 level

Academic major had a mixed on the Neumann Index. For instance, in the pooled model a humanities major decreased the proportion of occasions recommended for early promotion, while other majors had no effect. In the surface community model,

humanities majors had no effect, while social science/management majors increased the proportion of occasions an officer was recommended for early promotion and general science majors decreased it. Academic major was not significant in the submarine community.

The effect of race was also significant in all three models. The proportion of occasions which the officer was recommended for early promotion was lower by 2 percentage points for non-white officers.

Year groups were also found to be highly significant in the models using Neumann's dependent variable. As can be seen in Table 15 the same trend for each year group that was observed using the Bowman Index.

3. Retention Model

The full results of estimating the retention models are presented in Appendix B Tables B.7 through B.9. The results from the submarine community model are unreliable. Because of a lack of variation for the warfare qualification and non-white dummy variables, the logit model fails to accurately compute a coefficient for those variables. This in turn may bias the coefficients on the remaining variables. Therefore, the retention model for the submarine community is included in Appendix B, (Table B.9), but is not discussed in this section.

The effect of commissioning source on the probability of an officer being retained at least one year beyond a minimum

TABLE 15. THE EFFECT (IN PERCENT) OF YEAR GROUP ON THE NEUMANN INDEX

Year Group	Pooled Model	Surface Community	Submarine Community
'78	2.0	1.9	5.9
'79	3.0 *	16.7	13.0 *
'80	7.5 *	4.5	21.6 *
'81	9.8 *	7.4 *	22.6 *
'82	11.4 *	7.4 *	32.7 *
'83	11.5 *	4.0	35.2 *
'84	13.4 *	10.3 *	32.0 *
'85	17.7 *	11.7 *	41.8 *

* denotes significance at 0.10

service obligation was occasionally significant. Receiving a commission from OCS decreased the probability of being retained by 1.5 percentage points as compared to an officer from USNA, while NROTC was not significantly different. Similar tendencies were found in the surface community.

Obtaining a warfare qualification increased the probability of being retained by seven percentage points, while an engineering qualification decreased the probability by two percentage points. The complete results of the

TABLE 16. The EFFECT (IN PERCENTAGE POINTS) OF QUALIFICATIONS ON THE PROBABILITY OF OFFICERS REMAINING ON ACTIVE-DUTY AT LEAST ONE YEAR PAST AN INITIAL MINIMUM SERVICE OBLIGATION

Model	Warfare	Engineering
Pooled	11.6 *	- 2.9 *
Surface Community	7.7 *	- 2.0 *

* denotes significance at 0.10

qualification dummy variables, all of which were statistically significant at the 0.10 level, can be seen in Table 16.

The effect of academic major was significant only for general science majors in the surface community; increasing the probability of being retained by 2.3 percentage points. The effect of academic major can be seen in Table 17.

TABLE 17. THE EFFECT (IN PERCENTAGE POINTS) OF ACADEMIC MAJOR ON THE PROBABILITY OF OFFICERS REMAINING ON ACTIVE-DUTY AT LEAST ONE YEAR BEYOND A MINIMUM SERVICE REQUIREMENT AS COMPARED TO AN ENGINEERING MAJOR

Model	Gen. Sci.	Soc. Sci.	Hum.
Pooled	1.0	0.2	1.2
Surface Community	2.3 *	1.5	0.10

* denotes significance at 0.10 level

Non-whites were less likely to be retained in the pooled model by 2.1 percentage points. No significant effects of race were observed in the surface community.

Year groups were also statistically significant. Table 18 shows another trend present in year groups. Each subsequent year group from the base case of year group 77 was less likely to be retained at least one year beyond a minimum service requirement.

TABLE 18. THE EFFECT (IN PERCENTAGE POINTS) OF YEAR GROUPS ON THE PROBABILITY OF AN OFFICER REMAINING ONE YEAR BEYOND A MINIMUM SERVICE REQUIREMENT AS COMPARED TO YEAR GROUP '77

Year Group	Pooled Community	Surface Community
'78	15.8	14.7
'79	16.9	18.1
'80	6.1	7.8
'81	7.9	7.5
'82	5.9	4.0

All values were statistically significant at the 0.10 level

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

It is apparent that there are performance differences between officers from the Naval Academy, NROTC, and OCS. Naval Academy graduates tend to have a higher probability of being rated superior performers as compared to NROTC or OCS graduates. Depending on which model is reviewed, Bowman's or Neumann's performance index with the pooled or separate warfare communities, the results vary in significance and meaning. The largest difference in performance, using Bowman's dependent variable, was found in the submarine community, where NROTC graduates were five percentage points less likely to be superior performers than were Naval Academy graduates.

Examining the proportion of occasions recommended for early promotion finds Naval Academy graduates again leading the pack, but only by a small margin. NROTC and OCS graduates averaged four percentage and six percentage points, respectively, behind officers who graduated from the Naval Academy.

Even though commissioning source was not significant in every model, and the differences between sources were generally small, it can be seen that Naval Academy graduates

outperform NROTC or OCS graduates, based on the measures developed in this thesis.

The control variables used in this analysis also provided some interesting results. Intuitively, an officer who is warfare- or engineering-qualified would be rated higher on fitness reports than an officer who is not qualified, everything else being equal. All performance models confirmed this hypothesis. Attaining a warfare or engineering qualification has a dramatic effect on the probability of being rated a superior performer and on the proportion of occasions recommended for early promotion. Consequently, an officer who has attained one or both of these qualifications is more productive than one who has not, everything else being equal, based on the performance indicators in this thesis.

The effect of academic major was inconsistent, and the dummy variables for the academic majors were only occasionally significant. Therefore the type of undergraduate education an officer has received appeared to have little relevance to the productivity of that officer.

The reasons for trends found in the year group dummy variables is unclear. This is an interesting area for further research. A thorough review of the computations for the performance indices did not reveal any logic errors.

The possible reasons for the effect of race in the estimated models is also unclear and warrants further research.

Retention of officers beyond an initial service obligation is not directly related to productivity, but if officers from different accession sources serve significantly longer than others, it is an added return on investment to the Navy. The results of this study find that OCS officers were slightly less likely than Naval Academy graduates to be retained at least one year beyond a minimum service requirement, while there were no significant differences between NROTC and Naval Academy graduates.

Based upon the results of this thesis, it is reasonable to conclude that an officer who does not receive a warfare qualification is less likely to stay on active-duty, and that an engineering-qualified officer may have more civilian opportunities, thus making him less likely to stay beyond a minimum service requirement.

Academic major had little effect on the retention of officers. However, race and year groups were statistically significant. This study found minorities less likely to be retained which is contrary to other studies that examined the retention tendencies of minorities (Gilroy and Lakhani 1986, 250). The reason for this is unclear. It is also unclear why the declining retention for subsequent year groups is present.

B. RECOMMENDATIONS

Before any decision can be made concerning the future of Naval officer commissioning programs, several other areas involving the performance, value, and cost-effectiveness of commissioning programs must be evaluated. While this thesis suggests that Naval Academy graduates are more productive than officers commissioned from NROTC or OCS, further research is needed, before a set of firm conclusions can be reached.

Several explanatory variables were used in these models in an effort to isolate the independent effect of commissioning source on performance. However, there may be other factors that affect performance which have been omitted from the models. If relevant variables are omitted from the models a specification bias is introduced. For instance, the ship type on which the officer served and the officer's occupational specialty may affect performance. These variables were considered for inclusion here, but were rejected because of the time required in coding the dummy variables. Age and personal awards or decorations are examples of other control variables that could be added to the models used in this thesis. Finally, women could be added to the sample to determine gender differences in performance. If the added explanatory variables prove to be significant,

a clearer picture of the effect of commissioning source would emerge.

Additional measures of performance should also be tested. A multivariate technique applied to promotability (e.g. time to promotion to commander) and/or length of service would provide additional information that would assist policy makers in deciding how and where funding for commissioning programs should be cut, if at all.

Before any commissioning program is modified or has its budget cut, a thorough examination of the marginal costs involved in commissioning an officer through the program should also be conducted. Average costs are commonly discussed because they are easier to obtain. However, the problem with looking at average costs is that they only reflect the savings or additional costs for a large change in the number of officers commissioned through a given program. There are many aspects of the average costs that would not change with <u>marginal</u> changes in the number of potential officers participating in a program. This is a very crucial area for further research.

Although the commissioning programs examined in this thesis have the same basic mission, the purpose each serves is significantly different. The Naval Academy provides prospective officers with a large amount of training and

education directly related to the Navy. They carry with them into the fleet the history and customs inbred into the Navy way of life. The education and training they receive at the academy may appear to be quite costly, but they appear to be more productive officers.

NROTC offers a less costly means in providing highly-educated and well-trained officers. The large number of officers commissioned from this program differ only slightly in performance from academy graduates, thus making this an ideal source for the majority of new officers.

Although OCS officers may not perform as well as academy officers, the program allows a flexible and relatively inexpensive means to meet annual end-strength requirements. OCS also provides many of the specialized officers required to support the day-to-day activities of the fleet.

Based upon these primary purposes, neither of the commissioning sources should be eliminated entirely. Instead, there is some optimal combination that provides the most cost-efficient mix of officers for the Navy. Determining this combination should be the goal of future research.

APPENDIX A. NAVY OFFICER FITNESS REPORT

1. NAME (LAST, FIRST, MIDDLE) | 2. GRADE | 3. DESIG | 4. SSN

5. ACDUTRA/TEMAC | 6. UIC | 7. SHIP/STATION | 8. DATE REPORTED

OCCASION FOR REPORT: 9. PERIODIC | 10. DETACHMENT OF REPORTING SENIOR | 11. DETACHMENT OF OFFICER

PERIOD OF REPORT: 12. FROM | 13. TO

TYPE OF REPORT: 14. REGULAR | 15. CONCURRENT | 16. SPECIAL | 17. OPS CDR

BASIS FOR OBSERVATION: 18. CLOSE | 19. FREQUENT | 20. INFREQUENT

21. EMPLOYMENT OF COMMAND (CONTINUED ON REVERSE SIDE OF RECORD COPY) | 22. DAYS OF COMBAT

23. REPORTING SENIOR (LAST NAME, FI, MI) | 24. TITLE | 25. GRADE | 26. DESIG | 27. SSN

28. DUTIES ASSIGNED (CONTINUED ON REVERSE SIDE OF RECORD COPY)

SPECIFIC ASPECTS OF PERFORMANCE (TYPE IN OCR CODE LETTER FROM WORK SHEET)
29. GOAL SETTING & ACHIEVEMENT | 30. SUBORDINATE MANAGEMENT & DEVELOPMENT | 31. WORKING RELATIONS | 32. EQUIP & MATERIAL MANAGT | 33. NAVY ORGAN SUPPORT

A

34. RESPONSE IN STRESSFUL SITUATIONS | 35. EQUAL OPPORTUNITY | 36. SPEAKING ABILITY | 37. WRITING ABILITY

WARFARE SPECIALTY SKILLS (FROM OCR WORK SHEET)
38. SEAMANSHIP | 39. AIRMANSHIP | 40. WATCH STANDING | 41. TACTICAL PROFICIENCY | 42. LEADERSHIP | 43.

44. SUBSPECIALTY CODE

REQUIRED BY BILLET: 45. YES | 46. NO

UTILIZATION: 47. FREQUENT | 48. INFREQUENT | 49. NONE

(WORK SHEET CODE) 50. PERFORMANCE

MISSION CONTRIBUTION	NOT OBS	HIGH				MID		LOW MARG	UNSAT
51. EVALUATION									
52. SUMMARY									

TREND OF PERFORMANCE: 53. FIRST REPORT | 54. CONSISTENT | 55. IMPROVING | 56. DECLINING

B

DESIRABILITY (TYPE IN OCR CODE FROM WORK SHEET): 57. COMMAND | 58. OPERATIONAL | 59. STAFF | 60. JOINT/OSD | 61. FOREIGN SHORE

RECOMMENDATION FOR PROMOTION: 62. EARLY | 63. REGULAR | 64. NO

RANKING FOR EARLY PROMOTION: 65. NUMBER RECOMMENDED | 66. RANKING

PERSONAL TRAITS (TYPE IN OCR CODE FROM WORK SHEET)
67. JUDGMENT | 68. IMAGINATION | 69. ANALYTIC ABILITY | 70. PERSONAL BEHAVIOR | 71. FORCEFULNESS | 72. MILITARY BEARING

C

73 | 74 | 75 | 76

WEAKNESSES DISCUSSED?: 77. NONE NOTED | 78. YES | 79. NO

STATEMENT: 80. NOT DESIRED | 81. ATTACHED

D

82. SIGNATURE OF OFFICER EVALUATED (IAW BUPERS INST 1611.12 SERIES) "I ACKNOWLEDGE THAT I HAVE SEEN THIS REPORT, HAVE BEEN APPRISED OF MY PERFORMANCE AND RIGHT TO MAKE A STATEMENT."

E

83. DATE FORWARDED | 84. RES PART

85. SIGNATURE OF REPORTING SENIOR

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APPENDIX B. MODEL RESULTS

TABLE B.1.A LOGIT RESULTS USING THE BOWMAN INDEX FOR THE POOLED SAMPLE

Variable	Coefficient	Delta
INTERCEPT	- 2.071 (64.05)	N/A
ROTC	- 0.315 ** (8.33)	- 0.028
OCS	- 0.201 * (2.59)	- 0.018
WARFARE QUALIFIED	1.127 ** (41.33)	0.168
ENGINEERING QUALIFIED	0.628 ** (41.32)	0.079
SOCIAL SCIENCE/ MANAGEMENT	- 0.051 (0.18)	- 0.005
GENERAL SCIENCE	- 0.009 (0.01)	- 0.001
HUMANITIES	- 0.618 ** (7.885)	- 0.048

N=2158
chi-square values in parentheses
* denotes significant at 0.10
** denotes significant at 0.05

TABLE B.1.B LOGIT RESULTS USING THE BOWMAN INDEX FOR THE POOLED SAMPLE

Variable	Coefficient	Delta
NON-WHITE	- 0.732 **	- 0.055
	(12.46)	
YEAR GROUP '78	0.399 *	0.046
	(2.71)	
YEAR GROUP '79	0.880 **	0.121
	(13.70)	
YEAR GROUP '80	1.003 **	0.144
	(19.52)	
YEAR GROUP '81	1.161 **	0.175
	(26.52)	
YEAR GROUP '82	1.212 **	0.186
	(30.37)	
YEAR GROUP '83	1.775 **	0.315
	(62.56)	
YEAR GROUP '84	1.514 **	0.252
	(47.52)	
YEAR GROUP '85	2.043 **	0.381
	(77.14)	

n=2158
chi-square values in parentheses
* denotes significant at 0.10
** denotes significant at 0.05

TABLE B.2.A LOGIT RESULTS USING THE BOWMAN INDEX FOR THE SURFACE COMMUNITY

Variable	Coefficient	Delta
INTERCEPT	- 2.329 (50.31)	N/A
ROTC	- 0.218 (2.16)	- 0.016
OCS	- 0.168 (1.11)	- 0.013
WARFARE QUALIFIED	1.143 ** (31.98)	0.145
ENGINEERING QUALIFIED	0.600 ** (19.69)	0.062
SOCIAL SCIENCE/ MANAGEMENT	0.198 (1.73)	0.017
GENERAL SCIENCE	0.220 (1.69)	0.019
HUMANITIES	- 0.242 (0.98)	- 0.018

n=1270
chi-square values in parenthese
* denotes significant at 0.10
** denotes significant at 0.05

TABLE B.2.B LOGIT RESULTS USING THE BOWMAN INDEX FOR THE SURFACE COMMUNITY

Variable	Coefficient	Delta
NON-WHITE	- 0.643 ** (7.73)	- 0.040
YEAR GROUP '78	0.712 ** (4.90)	0.077
YEAR GROUP '79	1.052 ** (11.64)	0.129
YEAR GROUP '80	1.018 ** (11.96)	0.124
YEAR GROUP '81	1.152 ** (15.75)	0.147
YEAR GROUP '82	0.990 ** (12.00)	0.119
YEAR GROUP '83	1.537 ** (25.95)	0.223
YEAR GROUP '84	1.386 ** (22.99)	0.191
YEAR GROUP '85	1.977 ** (41.47)	0.324

n=1270
chi-square values in parentheses
* denotes significant at 0.10
** denotes significant at 0.05

TABLE B.3.A LOGIT RESULTS USING THE BOWMAN INDEX FOR THE SUBMARINE COMMUNITY

Variable	Coefficient	Delta
INTERCEPT	- 1.528 (9.91)	N/A
ROTC	- 0.402 ** (5.59)	- 0.051
OCS	- 0.334 (2.10)	- 0.044
WARFARE QUALIFIED	0.777 ** (4.06)	0.142
ENGINEERING QUALIFIED	0.488 ** (9.87)	0.083
SOCIAL SCIENCE/ MANAGEMENT	- 0.303 (1.17)	- 0.040
GENERAL SCIENCE	- 0.179 (1.03)	- 0.025
HUMANITIES	- 2.651 ** (6.02)	- 0.163

n=888
chi-square values in parenthese
* denotes significant at 0.10
** denotes significant at 0.05

TABLE B.3.B LOGIT RESULTS USING THE BOWMAN INDEX FOR THE SUBMARINE COMMUNITY

Variable	Coefficient	Delta
NON-WHITE	- 0.878 * (3.19)	- 0.096
YEAR GROUP '78	0.098 (0.07)	0.015
YEAR GROUP '79	0.588 (2.47)	0.103
YEAR GROUP '80	1.012 ** (7.92)	0.195
YEAR GROUP '81	1.202 ** (10.79)	0.241
YEAR GROUP '82	1.654 ** (21.67)	0.353
YEAR GROUP '83	2.066 ** (35.86)	0.453
YEAR GROUP '84	1.794 ** (26.75)	0.388
YEAR GROUP '85	2.191 ** (34.77)	0.482

n=888
chi-square values in parentheses
* denotes significant at 0.10
** dentoes significant at 0.05

TABLE B.4 OLS RESULTS USING THE NEUMANN INDEX FOR THE POOLED SAMPLE

Variable	Coefficient	t-value
INTERCEPT	0.202	5.438
ROTC	- 0.048 **	- 2.500
OCS	- 0.062 **	- 3.390
WARFARE QUALIFIED	0.222 **	9.719
ENGINEERING QUALIFIED	0.159 **	10.818
SOCIAL SCIENCE/MANAGEMENT	0.004	0.249
GENERAL SCIENCE	0.021	1.100
HUMANITIES	- 0.061 **	- 2.228
NON-WHITE	- 0.083 **	- 3.168
YEAR GROUP '78	0.020	0.551
YEAR GROUP '79	0.030	0.862
YEAR GROUP '80	0.075 **	2.189
YEAR GROUP '81	0.098 **	2.943
YEAR GROUP '82	0.114 **	3.470
YEAR GROUP '83	0.115 **	3.445
YEAR GROUP '84	0.134 **	3.966
YEAR GROUP '85	0.177 **	4.767

n=1695, adj. r2= .189
* denotes significant at 0.10
** denotes significant at 0.05

TABLE B.5 OLS RESULTS USING THE NEUMANN INDEX FOR THE SURFACE COMMUNITY

Variable	Coefficient	t-value
INTERCEPT	0.198	4.733
ROTC	- 0.040 *	- 1.785
OCS	- 0.064 **	- 2.956
WARFARE QUALIFIED	0.223 **	9.199
ENGINEERING QUALIFIED	0.152 **	8.852
SOCIAL SCIENCE/MANAGEMENT	0.037 *	1.814
GENERAL SCIENCE	0.042 *	1.810
HUMANITIES	- 0.039	- 1.272
NON-WHITE	- 0.071 **	- 2.574
YEAR GROUP '78	0.019	0.453
YEAR GROUP '79	0.017	0.428
YEAR GROUP '80	0.045	1.174
YEAR GROUP '81	0.074 **	1.980
YEAR GROUP '82	0.074 **	2.025
YEAR GROUP '83	0.040	1.058
YEAR GROUP '84	0.103 **	2.746
YEAR GROUP '85	0.117 **	2.767

n=1319, adj. r2.= .169
* significant at 0.10
** significant at 0.05

TABLE B.6 LOGIT RESULTS USING THE NEUMANN INDEX FOR THE SUBMARINE COMMUNITY

Variable	Coefficient	t-value
INTERCEPT	0.099	1.076
ROTC	- 0.039	- 1.108
OCS	- 0.066 *	- 1.846
WARFARE QUALIFIED	0.226 *	3.244
ENGINEERING QUALIFIED	0.135 **	4.587
SOCIAL SCIENCE/MANAGEMENT	0.013	0.256
GENERAL SCIENCE	0.007	0.226
HUMANITIES	0.049	0.609
NON-WHITE	- 0.169 **	- 2.135
YEAR GROUP '78	0.060	0.723
YEAR GROUP '79	0.130 *	1.744
YEAR GROUP '80	0.216 **	2.969
YEAR GROUP '81	0.226 **	3.101
YEAR GROUP '82	0.327 **	4.473
YEAR GROUP '83	0.352 **	5.032
YEAR GROUP '84	0.320 **	4.188
YEAR GROUP '85	0.418 **	5.326

n=376, adj. r2=.225
* denotes significant at 0.10
** denotes significant at 0.05

TABLE B.7.A RETENTION MODEL FOR THE POOLED SAMPLE

Variable	Coefficient	Delta
INTERCEPT	- 2.816 (73.48)	N/A
ROTC	- 0.011 (0.00)	- 0.001
OCS	- 0.331 ** (3.86)	- 0.015
WARFARE QUALIFIED	1.251 ** (20.94)	0.116
ENGINEERING QUALIFIED	- 0.754 ** (27.78)	- 0.029
SOCIAL SCIENCE/ MANAGEMENT	- 0.041 (0.06)	- 0.002
GENERAL SCIENCE	0.173 (1.05)	0.010
HUMANITIES	- 0.255 (0.86)	- 0.012

n=1698
chi-square values in parentheses
* denotes significant at 0.10
** denotes significant at 0.05

TABLE B.7.B RETENTION RESULTS FOR THE POOLED SAMPLE

NON-WHITE	- 0.491 * (3.08)	- 0.021
YEAR GROUP '78	1.520 ** (44.73)	0.158
YEAR GROUP '79	1.580 ** (62.06)	0.169
YEAR GROUP '80	0.801 ** (14.04)	0.061
YEAR GROUP '81	0.963 ** (23.36)	0.079
YEAR GROUP '82	0.785 ** (16.21)	0.059

N=1698
chi-square values in parentheses
* denotes significant at 0.10
** denotes significant at 0.05

TABLE B.8.A RETENTION MODEL FOR THE SURFACE COMMUNITY

Variable	Coefficient	Delta
INTERCEPT	- 3.022 (69.32)	NA
ROTC	0.038 (0.004	0.002
OCS	- 0.436 ** (4.76)	- 0.016
WARFARE QUALIFIED	1.060 ** (14.33)	0.077
ENGINEERING QUALIFIED	- 0.570 ** (11.51)	- 0.020
SOCIAL SCIENCE/ MANAGEMENT	- 0.295 (2.26)	- 0.015
GENERAL SCIENCE	0.433 * (4.01)	0.023
HUMANITIES	0.034 (0.01)	- 0.001

n=1322
chi-square values in parenthese
* denotes significant at 0.10
** denotes significant at 0.05

TABLE B.8.B RETENTION MODEL FOR THE SURFACE COMMUNITY

NON-WHITE	- 0.337	- 0.013
	(1.37)	
YEAR GROUP '78	1.593 **	0.147
	(37.75)	
YEAR GROUP '79	1.799 **	0.181
	(61.01)	
YEAR GROUP '80	1.071 **	0.078
	(19.16)	
YEAR GROUP '81	1.039 **	0.075
	(19.96)	
YEAR GROUP '82	0.670 **	0.040
	(8.31)	

n=1322
chi-square values in parenthese
* denotes significant at 0.10
** denotes significant at 0.05

TABLE B.9.A RETENTION MODEL FOR THE SUBMARINE COMMUNITY

Variable	Coefficient	Delta
INTERCEPT	- 9.767 (0.12)	NA
ROTC	- 0.042 (0.02)	- 0.000
OCS	- 0.128 (0.14)	- 0.000
WARFARE QUALIFIED	9.016 (.)	0.320
ENGINEERING QUALIFIED	- 1.428 ** (24.31)	- 0.000
SOCIAL SCIENCE/ MANAGEMENT	- 1.450 ** (4.73)	- 0.000
GENERAL SCIENCE	- 0.356 (1.36)	- 0.000
HUMANITIES	- 0.555 (0.44)	- 0.000

n=376
chi-square values in parentheses
* denotes significant at 0.10
** denotes significant at 0.05

TABLE B.9.B RETENTION MODEL FOR THE SUBMARINE COMMUNITY

NON-WHITE	- 8.775 (.)	- 0.000
YEAR GROUP '78	1.211 ** (5.62)	0.000
YEAR GROUP '79	0.833 * (3.68)	0.000
YEAR GROUP '80	- 0.117 (0.06)	- 0.000
YEAR GROUP '81	1.041 ** (5.79)	0.000
YEAR GROUP '82	1.547 ** (14.40)	0.000

n=376
chi-square values in parentheses
* denotes significant at 0.10
** denotes significant at 0.05

APPENDIX C. LIKELIHOOD RATIO AND CHOW TESTS

The likelihood ratio test is a method to test for differences between two or more maximum likelihood regression equations. It uses the ratio of the likelihood function for the pooled model over the likelihood function for the separate community models. This ratio is distributed as a chi-square distribution with n degrees of freedom, where n is the number of restrictions.

If the critical chi-square value is less than the computed ratio value, the null which states that the coefficients of each regression equation are equal, is not accepted. The result of the likelihood ratio tests for the maximum likelihood models using Bowman's dependent variable is shown in Table C.1.

Since the computed chi-square is very close to the critical value at 0.01 level of significance, and not that much different than at the 0.05 level of significance, the evidence is not completely conclusive that the regression equations are significantly different.

The Chow test is very similar to the likelihood ratio test in that it tests for the differences between the coefficients of two or more linear regressions.

This test consists of computing an F value which is the ratio of residual sum of squares for the restricted and

TABLE C.1 Likelihood Ratio Test Results

	Restricted Likelihood Function	Unrestricted Likelihood Function	Computed Chi-square
Bowman	2682.90	2649.91	32.99
Critical Chi-square (n=16)			
32.00 at 0.01 level of significance			
26.30 at 0.05 level of significance			
Neumann	1586.09	1543.4	42.69
Critical Chi-square (n=13)			
27.69 at .01 level of significance			

unrestricted models while accounting for degrees of freedom and number of observations.

The critical F value is distributed with degrees of freedom (k,N1 + N2 - 2k). If the computed F is greater than the critical F value, do not accept the null hypothesis that the regressions are the same. The results of the chow test appear in Table C.2.

Since the null hypothesis is rejected, the regression coefficients are not equal.

TABLE C.2 CHOW TEST RESULTS

Restricted RSS	Unrestricted RSS
129.323	125.231

F=(129.323/16) / {125.231/(1319 + 376 - 32)}
=107.334

F critical (16, 1663) = 2.04 at 0.01 level of significance

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